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Title:
MOUNTING OF INTEGRATED CIRCUITS

Abstract:
A method of direct mounting of unpackaged integrated circuit modules or other components without the use of wire interconnections. To overcome the effects of thermal coefficient of expansion mismatch between the components (4) and a rigid substrate (1) a thin layer of compliant material (2) e.g. thermosetting elastomer, is applied to the rigid substrate base before deposition of metallic conductor patterns (3). The components are then soldered directly to the conductor pattern. Single-sided, double-sided and multilayer substrates can be provided by the method.

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GB 1492285
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(54) Mounting of integrated circuits

(57) In a method of direct mounting of unpackaged integrated circuit modules or other components without the use of wire interconnections a thin layer of compliant material (2) e.g. an uncured thermosetting elastomer is applied to a rigid substrate base (1) e.g. a metal or an insulator before curing of the elastomer layer (2) and subsequent deposition of metallic conductor patterns (3). This overcomes the effects of thermal coefficient of expansion mismatch between the components (4) and rigid substrate (1). Single-sided, double-sided and multilayer substrates can be provided by the method.

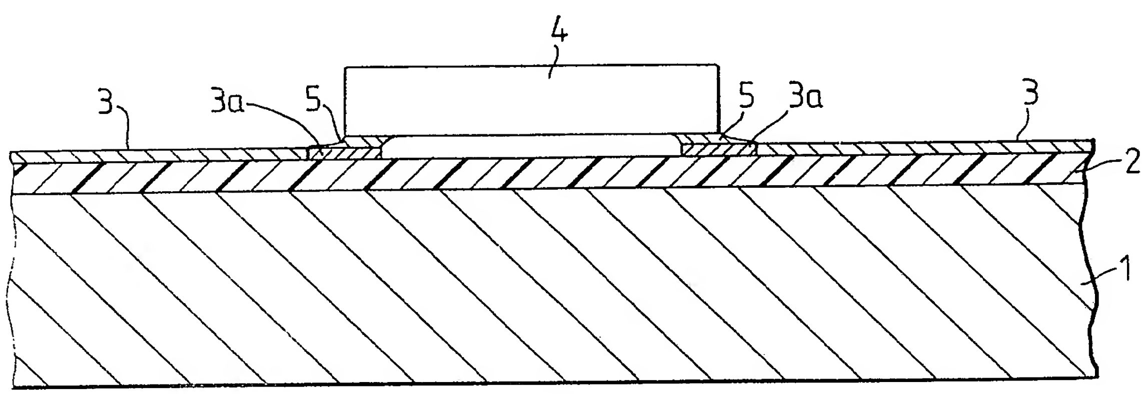

Fig.1.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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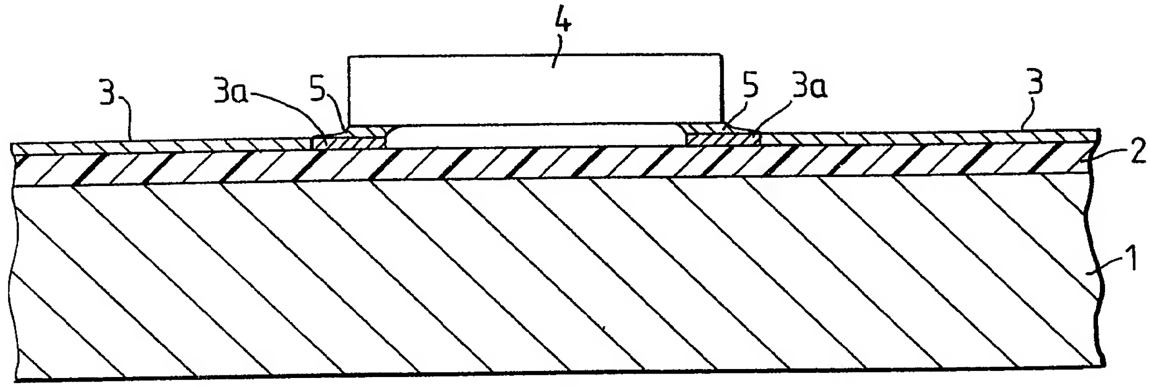

Fig.1.

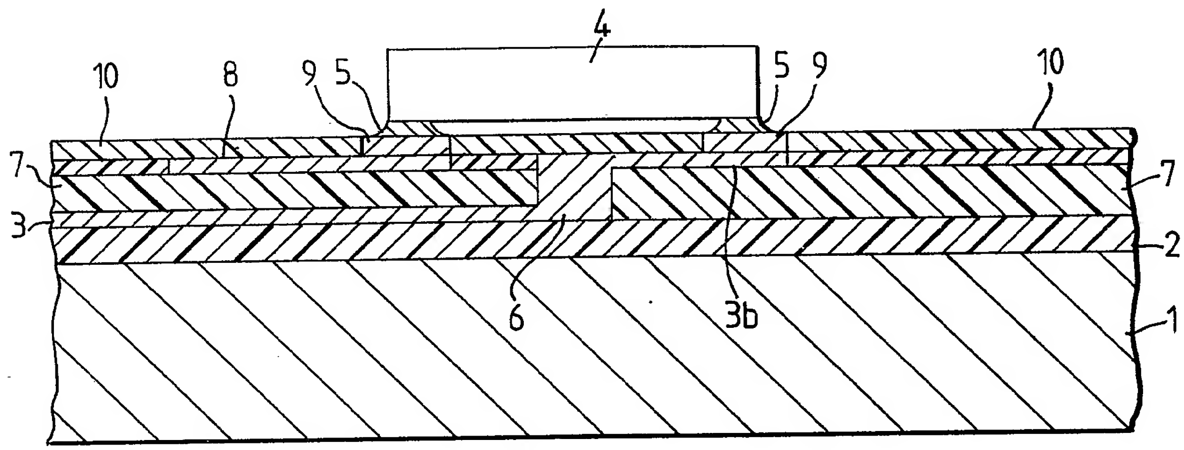

Fig.2.

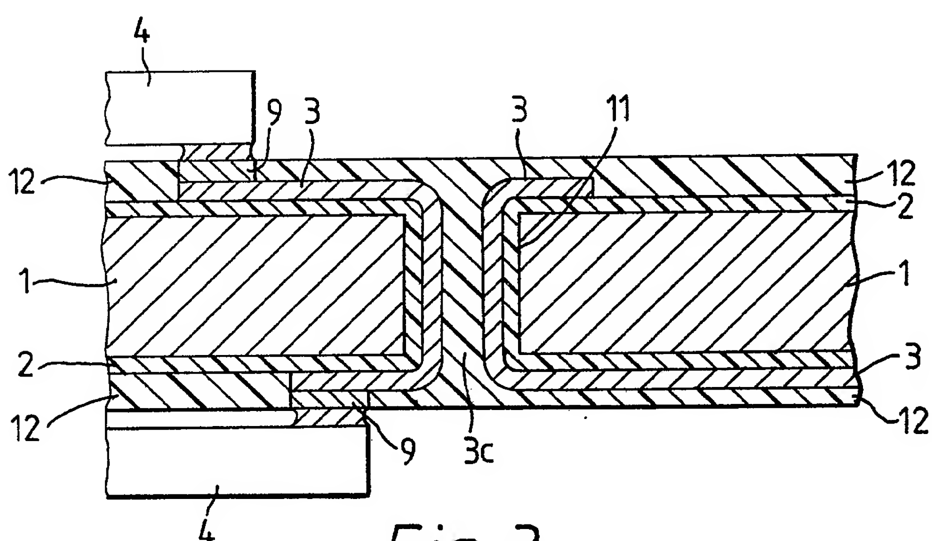

Fig.3.

SPECIFICATION
Mounting of integrated circuits, semiconductor devices and components

This invention relates to interconnection substrates for surface mounting of circuit elements in the form of unpackaged (bare) integrated circuit chips for autowire bonding, of chips carried on tape for tape automated bonding, and of packaged chips in ceramic or plastics leadless chipcarriers, all of which are hereinafter referred to as 'components'.

It is known that in electronic systems increased systems performance, as indicated by reduced circuit and system delay times, is achievable by the use of increased integration at the chip level. It is also known that the increase in level of integration is associated with the increase in the signal pin out requirement. The dominant form of chip packaging at present is the dual in line package configuration where the signal pin outs are formed such that they can be inserted into component mounting holes in the well known plated-through-hole printed circuit boards. This packaging configuration imposes severe limitations on systems performance due to both the penalty imposed on the area available for interconnection on the substrate and the electrical performance of circuitry. The development of large and very large scale integration (LSI and VLSI) and very high speed integrated circuits (VHSIC) in turn require an increasing number of signal pin outs, hence the present trend towards advanced techniques of chip packaging and attachment on the surface of the interconnection substrate.

Single and multilayer thick film hybrid ceramic substrate for interconnection between components in the forms of bare chips and for surface attachment of leadless ceramic chip carriers are already in use due to the apparent advantage of the match of the thermal coefficient of expansion of silicon and alumina (which will be detailed later). Ceramic substrates, however suffer from some disadvantages such as high dielectric constant, limited area for interconnection, limited conductor width and spacing (dictated by accuracies achievable with screen printing techniques), and high costs of some of the materials used, e.g. gold, in conductor inks.

Consider the stresses at the junction between the components and the substrate due to differential thermal levels are due to the forces F expressed by:

$$F \propto A x (\alpha_c - \alpha_s) x \frac{Es}{Es/Ec+1}$$

where A is the cross sectional area of the junctions

α_c coefficient of thermal expansion of component

α_s coefficient of thermal expansion of substrate

ΔT temperature differential

Es Elastic modulus of substrate

Ec Elastic modulus of component and

$$E = \frac{Es}{Es/Ec+1} \quad E \to 0 \text{ as } Es \to 0$$

This term also appears in other stress functions for mechanical or other loading conditions. Therefore the following applies,

For a finite temperature differential between component and substrate and for a finite junction area, the forces at the junction may be rendered very small when either or both the following conditions is satisfied.

$$\alpha_c \to \alpha_s \qquad (1)$$

$$E_s \to 0 \qquad (2)$$

Condition (1) may be satisfied by using materials with matched thermal expansion which is the case with thick film hybrid ceramic substrates as outlined above.

Condition (2) may be satisfied when using a substrate with very low elastic modulus.

Another source of stress between directly mounted components and the printed circuits upon which the components are mounted is flexure of the printed circuit substrate due to external loads. This is particularly relevant where the substrate is made from materials such as paper based laminated sheet bonded with epoxy resins. One way of eliminating the disadvantages accruing from the direct mounting of leadless components on flexible printed circuit substrates is disclosed in British patent specification No. 1,565,748, which teaches special shaping and reduction in area of the solderable contact areas to which the components are soldered.

According to the present invention there is provided a method of surface mounting of components including the step of providing between a rigid substrate base and a surface layer incorporating a conductor pattern, to which surface layer the components are secured by means of the electrical interconnections between the components and the pattern, an intermediate layer of a compliant insulating material.

The invention also provides a component assembly comprising a rigid substrate base carrying a compliant insulating layer on at least one face thereof, the compliant layer being provided on its surface remote from the rigid substrate base with a pattern of electrical conductors, and one or more components located on said remote surface, the component(s) being attached to the conductor pattern by electrical interconnections between the component(s) and the conductor pattern.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:—

Fig. 1 shows a method of mounting a component on a compliant substrate;

Fig 2 shows an alternative construction for a compliant substrate, and

Fig. 3 shows a construction for a double sided compliant substrate.

In the method shown in Fig 1 a substrate base 1 of a suitable rigid material (either insulating or conducting) has deposited on its surface a thin layer 2 of insulating elastomer with a low elastic modulus. The rigid base may be a metal, e.g. copper, aluminium, to promote good thermal conduction or an insulator such as a ceramic, glass reinforced plastic, epoxy, polyimide or PTFE. Conventional surface treatment of the base may be undertaken to improve the adhesion thereto of the elastomer layer. The elastomer layer 2 is then applied by dipping spraying, laminating, curtain coating, or otherwise coating the surface of the base. The elastomer layer 2 is preferably an uncured thermosetting polymer which when subsequently cured has suitable properties to accept the subsequently deposited metal conductor pattern. Polymers with known electrical properties and application comprise epoxy resins, polyimides, acrylonitrile butadienes etc. The applied polymer is then heat cured to the thermoset state, e.g. 160—250°C for 1—3 hours depending on the type of polymer. The surface of the cured polymer is then prepared in a conventional manner for the subsequent electroless deposition of metal, e.g. copper. A metal conductor pattern 3 is then electroless deposited on the prepared surface, the pattern comprising conductors terminating in pads or lands 3a where electrical interconnections are to be made with a superposed component. The electroless metal pattern is then electroplated to form the final conductor pattern. The component 4, which is formed with appropriate metallic contact areas, is then placed in position on the conductor pattern and interface junctions 5 are formed by soldering. Because of the compliance of the elastomer layer strain due to thermal expansion mismatch is not transmitted to the solder joints. It is obvious that the rigid base may be processed to provide for component mounting on both sides of the substrate.

Where more complicated interconnection arrangements are required, e.g. between a multiplicity of components mounted on a common substrate, it may be necessary to provide two or more interconnection layers on the same side of the substrate. Such an arrangement is shown in Fig. 2. The substrate 1 is first coated with a first thin elastomer layer 2 upon which the first conductor pattern 3 is formed, as previously described. Vertical interconnects or "vias" 6 are then formed by, e.g. well-known pillar plating techniques. A second elastomer layer 7 is then deposited, leaving the tops of the vias exposed. Additional metal disposition is then effected to provide a second conductor pattern 8 insulated from the first pattern. At the same time additional conductor patterns 3b may be formed which are extensions of the intial conductor pattern 3, being electrically connected thereto by the vias 6. Contact areas 9 are then formed and finally a thin elastomer layer 10 is applied overall leaving the contact areas 9 exposed for mounting the components in the manner previously described.

When two interconnection layers are required on either side of the substrate a construction such as that shown in Fig. 3 may be used. If the rigid base 1 is made of a conducting material, e.g. copper or aluminium, via holes 11 are initially punched or drilled and the first thin elastomer layer 2 is applied in such a manner as to coat the inside of the holes 11 as well as the flat surfaces of the base. The conductor patterns 3 are then formed, with parts of the pattern 3c forming plated through hole vias using the steps outlined above. Contact areas 9 are provided as before and the substrate is completed by applying a final elastomer coating 12.

For rigid bases made of an insulating material the initial layers of elastomer can be applied and cured before forming the via holes and the subsequent deposition of the metallic patterns. When more than two layers are required additional layers can be provided on one or both sides of the substrate using the steps outlined with reference to Fig. 2.

As an alternative to electroless deposition of metallic conductors it is possible to form patterns of conductive polymers which may be suitable in themselves without further metallisation or which may then be electroplated with metal. Where electroless plating is to be used several methods of achieving the conductor pattern are possible. The elastomer layer may be selectively treated to accept the electroless deposition and subsequent electroplating in a purely additive process. Alternatively the entire elastomer surface may be treated and electrolessly coated, following which a photoresist coating is applied, selectively exposed and processed to receive the electroplating, after which the unexposed photoresist and the underlying and unwanted electroless metal areas are removed. Yet again it is possible to incorporate a metal salt detector, e.g. copper salt detector, in the elastomer which, when selectively exposed to ultra violet radiation make a receptor for electroless deposition.

It will be appreciated that the thickness of the elastomer layer depends on the requirements of the finished product. The thicker the layer the more stress relief there will be between the component and the rigid substrate. Conversely the thinner the layer the better will be heat dissipation from the components via the substrate, particularly if the latter has a rigid metal base.

Claims

1. A method of surface mounting of components including the step of providing between a rigid structure base and a surface layer incorporating a conductor pattern, to which surface layer the components are secured by means of the electrical interconnections between the components and the pattern, an intermediate layer of a compliant insulating material.

2. The method according to claim 1 wherein additional layers of compliant insulating material and conductor patterns are provided between the surface layer and the intermediate layer, the additional conductor patterns are electrically connected to the surface layer by vertical interconnections formed through the intervening layers of compliant material.

3. The method according to claim 1 or 2 wherein the compliant layer(s) is made of a thermosetting elastomer material.

4. The method according to any preceding claim wherein the conductor patterns are initially formed of electroless deposited metal and subsequently electroplated.

5. The method according to any preceding claim wherein the rigid substrate base is made of metal.

6. The metal according to any one of claims 1—4 wherein the rigid substrate base is made of an insulating material.

7. The method according to claim 6 wherein the base is made of alumina ceramic, glass reinforced epoxy, polyimide or PTFE.

8. The method according to any preceding claim wherein the rigid base is coated on both sides with compliant material and has conductor patterns on both sides.

9. The method according to claim 8 wherein conductor patterns on both sides are interconnected by conductor coated holes through the rigid substrate.

10. A method of surface mounting of components substantially as hereinbefore described with reference to Fig. 1 or Fig. 2 or Fig. 3 of the accompanying drawings.

11. A component assembly comprising a rigid substrate base carrying a compliant insulating layer on at least one face thereof, the compliant layer being provided on its surface remote from the rigid substrate base with a pattern of metallic conductors, and one or more components located on said remote surface, the component(s) being attached to the conductor pattern by electrical interconnections between the component(s) and the conductor pattern.

12. An assembly according to claim 11 having on each face a compliant layer provided on the surface thereof remote from the base with a pattern of metallic conductors to which components are attached by electrical connections between the components and the conductor patterns, the assembly including one or more holes through the base, said holes containing metallic interconnections between the metallic conductor patterns on the two faces of the substrate.

13. An assembly according to claim 11 or 12 including on the or each face an additional layer(s) of compliant insulating material and metallic conductor pattern(s) between the surface layer and the first mentioned compliant layer, the additional conductor layer(s) being connected to the surface conductor layer by vertical metallic interconnections formed through the intervening layer(s) of compliant material.

14. An assembly according to any one of claims 11—13 wherein the compliant material is a thermosetting elastomer.

15. An assembly according to any one of claims 11—14 wherein the rigid base is made of an insulating material.

16. An assembly according to claim 15 wherein the base is made of alumina ceramic, glass reinforced epoxy, polyimide or PTFE.

17. An assembly according to any one of claims 11—15 wherein the rigid base is made of metal.

18. A component assembly substantially as described with reference to Fig. 1 or Fig. 2 or Fig 3 of the accompanying drawings.

19. An electrical circuit board comprising a rigid substrate base carrying a conductor pattern on a side thereof, there being a compliant insulating intermediate layer between the case and the conductor pattern, the pattern being designed to receive surface mounted components connected directly to the pattern, the intermediate layer being such as to absorb differential thermal expansions which may occur between the components, when mounted, and the base.

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